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FID-TT 62-1759

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# TRANSLATION

PROGRAM CONTROL OF METAL CUTTING MACHINES  
(SELECTED ARTICLE)

By

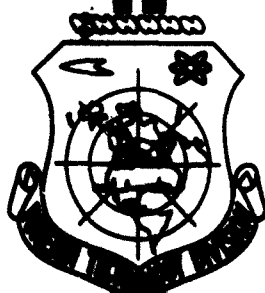
V. I. Kusnetsov

## FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

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## UNEDITED ROUGH DRAFT TRANSLATION

PROGRAM CONTROL OF METAL CUTTING MACHINES (SELECTED ARTICLE)

BY: V. I. Kuznetsov

English Pages: 7

SOURCE: Russian Book, Dostizheniya v Oblasti  
Tekhnicheskogo Progressa v SSSR,  
Proftekhizdat, 1961, pp 152-157

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## Program Control of Metal Cutting Machines

By  
V. I. Kuznetsov

Automation of industrial processes - one of the basic trends of technical progress in our country.

In machine construction automation is finding broad application first of all in mass manufacture. For example, at automobile, tractor and other mass production plants a predominant majority of machines works automatically or by the semiautomatic cycle, one after the other automatic lines are being put into operation, complex automatic workshops and plants are being created.

But in machine construction there are numerous plants with series and low scale manufacturing output. Under conditions of series and particularly small scale manufacture automated machines should remain universal and capable of rapid and simple transformation.

In recent years particularly great attention is being devoted to program control installations in metal cutting machines.

Program control in metal cutting machines opens possibilities for broad introduction of automation into small scale and even into individual manufacture.

In mass manufacture program control makes the technological process more flexible, it allows with relative ease to bring in changes into the manufacturing technology and into the construction of the object as well.

Program control allows: a) to automate conventional universal equipment; b) control simultaneously several machines from one control desk; c) organize a central preparation point (even away from the plant) of program development, which can be easily multiplied and transferred from one plant to another; this will enable to manufacture identical and interchangeable details at various enterprises or again orga-

nize the manufacture of details after a long pause in their manufacture; programs can be "stored" at the library for unlimited time periods; d) to relatively easily and rapidly correct machining programs, almost without loss of time and means, and to induce structural changes as well.

Program control raises the coefficient of utilizing the equipment and reduces its idling; the most convenient cutting conditions are used, and the number of subsequent finishing operations can be reduced to a minimum.

Electronic computers, which appear to be a component part of the program control system, allow to considerably raise the accuracy and rate of machining difficult profiles.

The flexibility of program control offers the possibility to technologists to properly distribute the change overs in machining processes, and to constructors the ability of constructing details with ideal technical qualities.

The cost of program control installations is about 20-40% of the cost of the machine, the output of the machine with program control rise many times.

Program control devices by their mode of operation can be divided into two larger groups: continuous action units and discrete action units.

Continuous action units are based on recording the outline of the machined detail on a primary document in form of a continuous curve. Of maximum interest are photoelectric devices, as well as devices based on phase displacement, i.e. with phase control.

Photoelectric devices. In these devices on the primary document - photo film - is photographed from the drawing the contour of the machined detail, drawn in larger scale.

During the movement of the film the photoelement controls the support unit on the basis of the contour, recorded on this photo film.

The necessary detail is obtained by the summation of two movements: longitudinal,

which takes place at constant speed, and lateral (follow up), moving in dependence upon the position of the support during longitudinal displacement.

Phase control device. In role of primary document is used a magnetic tape, on which movements of the tool relative to the machined detail is recorded in form of phase modulated sinusoid.

Devices of this type can be used for the manufacture of small size details. The derived accuracy is relatively small (0.05 - 0.1 mm). This system requires the use of high accuracy selsyns.

Magnetic devices can record numerical data, as well as continuously changing electric voltages. In the most simple case on the magnetic tape are recorded three voltages of an ordinary selsyn-transmitter, fixing the magnitudes of mechanical displacement, and the reproduction of these voltages for controlling the selsyn-receiver.

Automation of machines can be realized with the aid of a command apparatus on the principle of magnetic recording.

On the magnetic tape are recorded programs in form of electric pulses. Reading of programs is done with the aid of a reproducing head through an amplifier, relay and magnetic starter of the driving electric motor. Each electric motor has a corresponding sound generator which gives off oscillations of specific frequency for magnetization of the recording head, with which all generators (oscillators) are connected.

An experimental program control was set up at the lathe-screw cutting machine 16-1A whereby the longitudinal and transverse feedings of the support was realized from individual electro-motors; machining accuracy was 0.25 mm in diameter and 0.2 mm in length.

The program of machining details is recorded on a magnetic tape during the manufacture of the first sample from the potentiometer through the thyatron amplifier, which controls the support shifting servomotor, kinematically connected with the selsyn transmitter.

During the automatic working cycle of the machine from the magnetic tape are

reckoned the pulses, which go to the amplifier. The displacement of pulses, going from the magnetic tape and over the feedback line, is proportional to the disagreement between the actual and required position of the support.

Such systems will be perfectly capable of working during the machining of details of medium complexity with an accuracy of the order of 0.10-0.15 mm in the case of using stable selsyn-feelers.

When manufacturing items of complex volumetric form, individual points of which are determined by mathematical formulas, it is advisable to use individual elements of fast acting electronic computers.

On a perforated tape are punctured coordinates of points for the conjugation of profile curves, characteristics of these curves and cutting conditions, and the computer computes the way of the cutting tool in the system of three coordinates.

New methods of processing, new types of drives and methods of controlling the machines create broad perspectives for further improvement of machines and for sharply raising labor output.

Discrete action control devices attained broadest application; they are used for controlling heavy duty jig-boring machines, lathes, copy milling machines etc. The basis of constructing discrete action control devices is the numerical follow up machine.

In this respect machine constructors have put in much work. They adopted several methods of programming, including magnetic tape recording and recording on drums; the construction of pitch motors has been developed; feedback systems are tested, particularly inductive, magnetic and optical; constructions of experimental machines have begun.

Constructed was a milling machine with program control. On this unit can be machined by the contour flat cams and details similar to them. The rotating table of the machine has a constant angular feed. The program is recorded on a motion picture film and is fed to relative radial displacement of the mill. The inconstancy of the opera.



tional feeding along the contour and the limitedness of employment lead to replacement of these machines with hydro copy machines, on which any given profiles can be milled with constant feed along the contour and by patterns made of thin sheeted steel.

There lathes with program control. The system of program controlling lathes during the turning of teeth of round broachings the program is set by selecting coordinates along disks existing on the command apparatus machine.

There are a number of other machines with program control.

Fig.60 shows a vertical bracket bearing copy milling machine with program control.

When automating machines the computer can be placed outside of the plant, and it can control simultaneously the operation of several machines.

But so far such installations represent singular experimental units, although there is no doubt, that in the future they will find broadest application within the framework of general complex automation of industry.

Thanks to the employment of new program control systems, developed on the basis of recent achievements of computation technology,

Fig.60. Vertical Bracket Bearing Copy-Milling Machine with program control, model 6H11KP.

it is possible to meet all the requirements for automated machines under conditions of series and small scale manufacture. Program control allows to solve still another important technical problem: with minimum loss of means and time to obtain details with complex curvilinear surfaces.

Program control of metal cutting machines with the aid of electronic computers

creates a real basis for total automation of industry. The greatest advantage of program control with the aid of electronic computers appears to be the possibility of creating flexible automation, allowing to realize rapid transition from the manufacture of one group of items into manufacture of others.

In recent years in the USSR were developed and introduced program control computers for controlling not only individual machines, but entire production lines.

To assure further development of this type of automation it is necessary to consider advisable in first place the development and introduction of program control into machines, intended for the manufacture of details of complex configuration, requiring high accuracy ( dies, turbine vanes, aircraft components, cams etc.).

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